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Fusiform Rust Infection of Loblolly and Slash Pines After Artificial Inoculation and Natural Exposure in Plantations

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Abstract.--Seedlings from progenies of slash and loblolly pines were divided into two groups. One group was exposed to the fusiform rust fungus in greenhouse inoculations by the concentrated basidiospore spray system and the other was exposed to natural infection in field progeny tests. Within families, correlations between percentages of seedlings infected after field and artificial exposure were 0.6 to 0.8 for three slash pine plantations and 0.4 to 0.6 for six loblolly pine plantations. Most progenies were highly susceptible to infection, particularly under artificial conditions. Greenhouse inoculations usually identified highly resistant progenies but not those with small amounts of resistance.

Keywords: Cronartium quercuum f. sp. fusiforme, Pinus elliottii, Pinus taeda.

With the rapid growth in plantation forestry in the South has come a drastic increase in losses caused by the southern fusiform rust fungus (Cronartium quercuum (Berk.) Miyabe ex Shirai f. sp. fusiforme) in plantings of slash (Pinus elliottii Engelm. var. elliottii) and loblolly (P. taeda L.) pines (Czabator 1971; Powers and others 1975; Schmidt and others 1974; Sluder 1977). Pine parents that bear rust-resistant progeny are badly needed, but such trees are rare.

To identify resistant trees, techniques for inoculating seedlings have been developed (Jewell 1960; Snow 1968; Matthews and Rowan 1972). The method developed by Matthews and Rowan, called the concentrated basidiospore spray (CBS) system, rapidly screens large numbers of seedlings from selected trees for resistance to fusiform rust. Trays of seedlings from the selected trees are sprayed with controlled volumes of a water suspension of basidiospores of known concentration, incubated in a moist chamber at 70° F, then placed in a greenhouse. The percentages of seedlings with galls are recorded 6 months later for slash pine or 9 months later for loblolly pine. From 120 to 200 seedlings of each progeny are inoculated, and at least one standard susceptible check lot is included in each run. Under the conditions of the test, progenies are consistently ranked as resistant, intermediate, or susceptible (Powers 1974), but the relationships between CBS ranking and

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field resistance have not been adequately studied. This paper describes a study of such relationships for several groups of slash and loblolly pine progeny in plantations in central and west-central Georgia.

MATERIALS AND METHODS

This study on the application of the CBS screening method was done cooperatively by the Tree Improvement Project at Macon, Georgia, and the Diseases of Southern Pines Project at Athens, Georgia. Nine plantations established between 1961 and 1974 were studied (table 1). Progenies were from controlled pollinations of clones of loblolly and slash pines in a seed orchard. Three plantations (57, 122-123, and 76) contained progenies from pollinations with a mix of pollen from several male parents; the other six plantations contained single-cross progenies.

The field design of the plantations was randomized blocks with plot sizes of 5, 16, or 25 trees and 4 to 10 replications. In individual plantations, from 15 to 140 trees per progeny were scored for rust symptoms (table 1). Most trees were 5 to 6 years old when scored, but those in one plantation were 3 years old.

Seeds in excess of needs for establishing the plantations were labeled and stored in a freezer. These stored seeds were used in CBS inoculation tests. However, not enough stored seeds were available for two of the plantations, numbers 57 (slash) and 76 (loblolly). In order to approximate these progenies, which were from a pollen mix used on the female parents, we collected wind-pollinated seeds from the female parents in the seed orchard. These progenies should closely approximate those in the field.

In the field, there was no replication of progeny sets over time, but

Table 1.--Study materials, test areas, and conditions for artificial inoculations and field tests in Georgia

Plantation		Field test			Greenhouse test		
Number	County	Year planted	Age scored (years)	Trees/ progeny	Inoculum density (M/ml)	Seedlings/ progeny	Number of progenies
				SLASH PINE			
57	Bleckley	1961	5	140	50	72	16[a]
78	Houston	1965	5	40	13	125	28[b]
122-123	Bleckley	1972	3	70	13	125	17[b]
				LOBLOLLY PINE			
76	Bleckley	1965	5	120	75	110	14[a]
95	Putnam	1967	5	15	75	100	14
96	Troup	1967	5	15	75	100	14
104	Putnam	1969	6	40	75	115	9
105	Heard	1969	6	40	75	115	9
131	Houston	1974	5	60	50	160	43

[a] For artificial inoculations, these progenies were approximately reconstituted by collecting wind-pollinated seeds from the appropriate clones in the seed orchard.

[b] These progenies were distributed in two adjacent plantations, with some progenies common to both. The data were adjusted for combined analysis.

there was some replication over location. The 14 progenies in plantations 95 and 96 were the same. Also, the nine in plantations 104 and 105 were the same (table 1).

Seedlings were artificially inoculated at age 6 weeks with basidiospores from a central Georgia source of C. quercuum f. sp. fusiforme. The inoculum densities used are listed in table 1. The number of seedlings screened per progeny varied from 72 to 160 for the different plantations (table 1). Susceptible checks were used. Disease ratio (DR)--percentage of test lot infected divided by percentage of susceptible check lot infected--was calculated for all the progenies except those in loblolly plantation 131.

Linear regressions and correlation coefficients were computed for each plantation to determine the relationship between field infection percentages and CBS screening DR (CBS screening infection percentages for progenies in plantation 131).

RESULTS AND DISCUSSION

Figure 1 shows data points and regression lines for one slash and one loblolly pine plantation. In these and in other plantations, progenies with relatively low DR in greenhouse tests had relatively low infection rates in the field. Thus, the greenhouse tests were reliable for identifying progenies with large amounts of resistance. Most of the progenies of both species were highly susceptible to infection, particularly when artificially inoculated. That is to be expected, since the parents of these progenies were not intensively selected for resistance to fusiform rust. Despite the high overall levels of susceptibility, significant correlations between natural and artificial infection results were found for all three slash pine plantations and for three of the six loblolly pine plantations (table 2). Similar studies using other inoculation techniques have been done on slash pine with results similar to our slash pine results (Dinus 1969; Goddard and Schmidt 1971).

The relationship between CBS and field results was very similar for progenies in paired plantations 95 and 96 and for progenies in paired plantations 104 and 105. Average field infection levels in plantations 95 and 96 differed by only 3 percentage points; in plantations 104 and 105, however, the difference was 22 percentage points

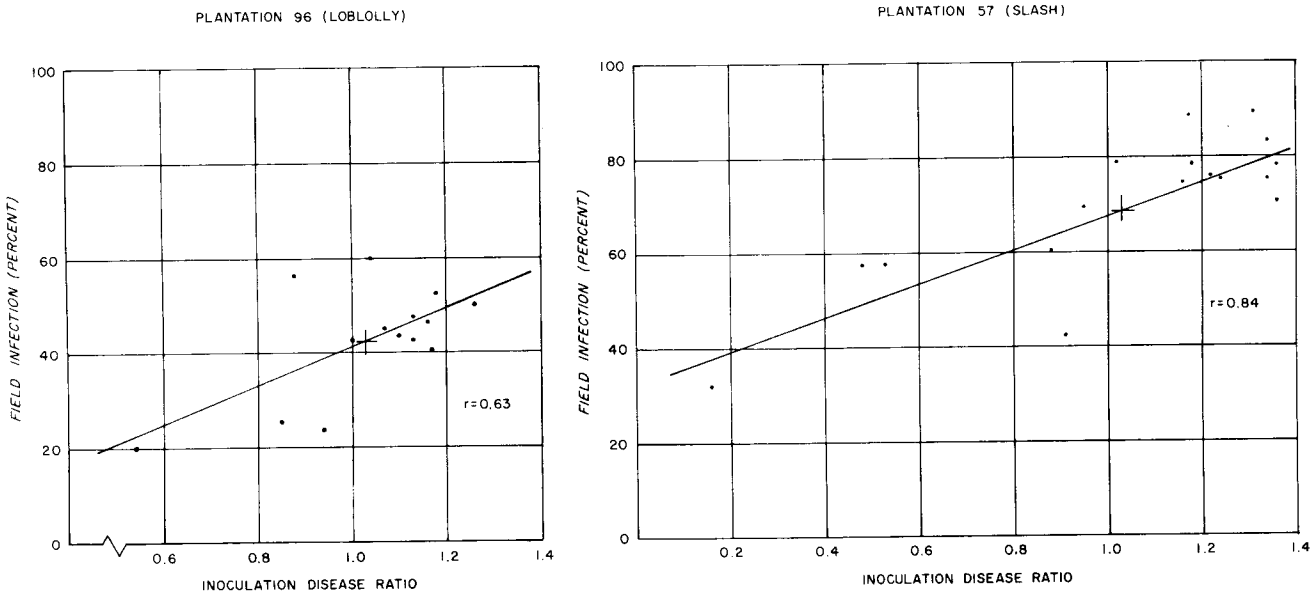

Figure 1.--Data points and correlation coefficients for one slash and one loblolly pine plantation, showing the relationship between inoculation disease ratio, a measure of infection based on a susceptible check lot, and field infection percentage.

(table 2). This consistency in correlation between CBS and field results for progenies planted in different locations is encouraging, particularly for plantations 104 and 105, which differed so much in average infection levels.

CBS inoculation is done under controlled conditions, but conditions in the field vary greatly over time and space. Sources of field variation include inoculum level, genetic makeup or virulence of the fungus (Powers 1980; Powers and others 1977), temperature and moisture, and the coincidence of optimum conditions for infection with inoculum levels. If progenies being tested ranked differently under different field conditions, the accuracy of CBS screening for predicting field performance will be impaired. There is evidence that loblolly pine progenies may not rank the same with CBS screening at different inoculum densities (Matthews and others 1978). In the present study, the few progenies with field resistance were accurately identified by CBS screening. In fact, the method appears to be conservative in picking out field resistant progenies in that only the very best are identified. The rating of almost all tested progenies as susceptible is discouraging in large-scale screenings however. Perhaps refinements in the screening method (Walkinshaw and others 1980) could increase its ability to detect progenies with a moderate level of field resistance. Also, as resistance genes accumulate in breeding populations, a greater range in resistance likely will develop, making the screening method more effective.

Table 2.--Average disease ratio (DR) for slash and loblolly pines in greenhouse inoculations, average percentage of seedlings infected in plantations, and correlation between greenhouse and field results

Plantation number	Greenhouse mean DR	Plantation mean % infection	Correlation coefficient (r)
		SLASH PINE	
57	1.03	69	0.84**
78	1.21	97	.68**
122-123	1.22	62	.62**
		LOBLOLLY PINE	
76	1.07	92	.51NS
95	1.03	46	.56*
96	1.03	43	.63*
104	1.04	55	.50NS
105	1.04	77	.42NS
131	76(%)	82	.42**

* Significant at the 0.05 level.
** Significant at the 0.01 level.
NS = Not significant.

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